1. Some of our favorite expressions:

Please use the speed of light \( c = 3.0 \times 10^8 \text{ m/s} \).

"Moving objects shrink" by a factor of \( 1/\gamma \) and "Moving clocks run slow" by a factor of \( \gamma \) where

\[
\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}
\]

\( v/c \) in terms of \( \gamma \) is

\[
\frac{v}{c} = \sqrt{1 - \frac{1}{\gamma^2}}
\]

"Simultaneity slips" The time in a moving frame between simultaneous events in another frame is

\[
T = \frac{vD}{c^2}
\]

The details: If events \( E_1 \) and \( E_2 \) are simultaneous in one frame then in a frame moving with speed \( v \) in the direction from \( E_1 \) to \( E_2 \), the event \( E_2 \) occurs earlier than \( E_1 \) by the time interval \( Dv/c^2 \), where \( D \) is the distance between the events in the second frame.

"Velocity addition is modified". An object moves at \( u \) in a frame. In another frame moving at \( v \) with respect to this frame, the object moves at \( w \) given by

\[
w = \frac{v + u}{1 + uv/c^2}
\]

"Light changes color" For observers with relative velocity \( v \)

\[
K = \frac{T'}{T} = \frac{\sqrt{1 + \frac{v}{c}}}{1 - \frac{v}{c}} = \gamma + \sqrt{\gamma^2 - 1} = z + 1
\]

where \( T' \) is in the frame that receives the light, \( T \) is in the frame that emits light. For receding observers \( v > 0 \), for approaching observers \( v < 0 \). The speed in terms of \( K \) is given by

\[
\frac{v}{c} = \frac{K^2 - 1}{K^2 + 1}
\]
The probability chart $P(m_b = +m_B | m_z = +m_B)$ vs. $\theta$

**Quantum Mechanics** The probability for a system to transition from state $A$ to state $B$ is found by

1. **Find the paths** List the exclusive, exhaustive ways or paths to transition from $A$ to $B$.
2. **Assign amplitudes** Determine the amplitudes for each path.
3. **Add amplitudes** Add the amplitudes for all possible paths “tip to tail”.
4. **Square to probability** Then the square of the length of the total amplitude is the probability for the transition.

**“Gravity slows clocks”** Alice and Bob are near a massive object that accelerates objects at $g$. If Alice is a height $h$ above Bob then when Alice’s clock clicks off $T_A$ then Bob’s clock ticks off $T_B$

$$T_B = T_A \left(1 - \frac{gh}{c^2}\right)$$

(to leading order).

The Schwarzschild radius of a black hole of mass $M$ is

$$r_s = \frac{2GM}{c^2}$$

where is Newton’s gravitational constant.

The Hawking temperature of a black hole of mass $M$ is, in degrees Kelvin,

$$T_H = 6 \times 10^{-8} \frac{M_\odot}{M}$$

where $M_\odot$ is the mass of the sun.